A Model Of Cournot Competition With Lobbying

Yoav Wachsman, Coastal Carolina University, USA
Jie Zhou, Coastal Carolina University, USA

ABSTRACT

Lobbying plays an integral part in the American political process. This paper utilizes game theory to examine the lobbying efforts of a duopoly that is competing for a government contract. We first examine a model with a general probability function and then solve a model with a specific probability function. We find that if the probability function is concave, then there exists a globally-stable Nash-Cournot equilibrium. Furthermore, total lobbying will increase with the size of the contract and the ease in which policymakers can be influenced and is likely to decrease with an increase in one of the firm's costs.

Keywords: Lobbying; Cournot Model; Game Theory; Political Influence

INTRODUCTION

Lobbying plays an integral part in the American political process. According to the Center for Responsive Politics, spending on lobbying reached $3.51 billion in 2010 and the number of registered lobbyists approached thirteen thousand. Lobbyists use a variety of methods, such as contributing to political campaigns, organizing rallies, and funding research, to gain political support from legislators and other public officials. Some of the top spenders of lobbying dollars are large corporations, such as Northrop Grumman, Exxon Mobile, Verizon Communications, Boeing, and Lockheed Martin, that are attempting to win lucrative government contracts. [1]

This paper utilizes game theory to study the lobbying efforts of a duopoly that is competing for a government contract (e.g., McDonnell Douglas and Lockheed Martin). We assume that when a firm increases its lobbying effort, that increases its probability of winning the contract and decreases its competitor's probability of winning the contract. Although other researchers have used a Nash-Cournot analysis, to the best of our knowledge, this is the first paper to use a probabilistic profit function to examine lobbying and the first to examine the strategic interaction among lobbyists who compete for a discrete benefit.

Lobbying is an important topic to study because it leads to economic inefficiencies. Olson (1965) argues, in a seminal paper, that interest groups hinder economic growth by reducing the effectiveness of market forces. Tullock (1967) and Bhagwati (1982) assert that lobbying shifts resources away from productive activities towards unproductive activities and, in some cases, leads to complete rent dissipation. Horgos and Zimmermann (2009) use a longitudinal analysis to demonstrate that growth is inversely related and inflation is directly related to the number of interest groups in the economy. Furthermore, Horgos and Zimmermann (2010) show that political stability increases lobbying because lobbyists are more certain that the officials that they lobby will continue to have political influence.

Increasingly, researchers are using game theory to examine the strategic interaction between lobbyists and policymakers. Grossman and Helpman (1996) use a game-theoretical model to argue that policymakers vote for policies that maximize the lobbying dollars they receive. Grossman and Helpman (2001) expand their theoretical analysis and demonstrate that lobbying results in a complex interaction among voters, interest groups, and policymakers.

[1] http://www.opensecrets.org/lobby

Felli and Merlo (2001), for instance, claim that policymakers select specific lobbyists that share a similar perspective and that chosen policies are typically a compromise between the policymakers' views and the desires of the lobbyists. Felli and Merlo (2006 and 2007) show that lobbyists typically contribute to legislators with a similar political perspective; however, if their preferred candidate fails to win an election, lobbyists are likely to contribute money to his or her opponent in order to induce a compromise. Epstein and Nitzan (2006) utilize a two-stage game with interest groups as principals and policymakers as agents. They find that when two interest groups compete for the favor a policymaker, the resulting policy can be more extreme and less efficient than either group intended.

A few authors focus on the strategic interaction among the lobbyists as this paper does. Hillman and Samet (1987) demonstrate that when groups compete over an indivisible prize, rent dissipation is complete even if the number of groups is small. Kahane (2002) examines a Cournot-Nash model where two groups compete for a continuous good such as water. He shows that the stronger the internal coordination within the group the worse off the group's members are since their net income decreases as a result of the group's higher lobbying effort.

We first examine a model with a general probability function and then solve a model with a specific probability function. We show that there exists a globally-stable Nash-Cournot equilibrium, with equilibrium levels of lobbying efforts. Our paper contributes to the literature by focusing on the strategic interaction among lobbyists as opposed to previous research which focuses on the interaction between lobbyists and policymakers or among an interest group's members. Furthermore, we utilize a unique and simple model where lobbying efforts affect the probability of winning a non-divisible benefit as opposed to previous papers that either utilize a non-stochastic model or a model with a divisible benefit. We feel that such a stochastic model is more realistic because policymaking is both complex and unpredictable. There are many factors that could influence which firm would win a contract besides lobbying efforts, including the voters' influence, the political prowess of the policymakers, and the public's perceptions of the lobbying firm.

THE GENERAL MODEL

Consider a model with two firms (i = 1, 2) that are lobbying to win a lucrative contract worth B. Each firm must choose how much lobbying, L_i, to engage in. Let P^i be the probability that firm i wins the contact, $0 \leq P^i \leq 1$. Additional lobbying by firm i increases the probability that firm i will win the contract, while additional lobbying by firm j, $j \neq i$, decreases the probability that firm i will win the contract. Also, we assume that the probability of winning the contract rises with the factor of influence, γ. We define the factor of influence as how easily policymakers can be influenced by lobbying.

$$P^i(\underset{+}{L_i}, \underset{-}{L_j}; \underset{+}{\gamma}), i = 1, 2, i \neq j \tag{1}$$

Naturally, we assume that the probability that firm i wins the contract increases if firm i increases its lobbying effort (L_i) and decreases if its competitor increases its lobbying effort (L_j). Lobbying effort is the amount of money and time that a firm spends lobbying policymakers to gain their support.

Each firm has a total production cost of C_i. We assume that the contact calls for a certain quantity of production as many government contracts do (for example, producing 100 airplanes for the military); thus, C_i is the total cost of fulfilling the contract. Each firm has a probability of P^i of winning the contract and a probability of $(1 - P^i)$ of losing the contract. Since firm I, winning the contract, and firm j, winning the contract, are exhaustive and mutually exclusive events, then $P^j = (1 - P^i)$. Both firms must pay their lobbying costs regardless of whether or not they win the contract. Let $E[\Pi^i]$ be the expected profit of firm i. Simplifying the expected profit:

$$E[\Pi^i] = P(L_i, L_j; \gamma)\left[B - C_i\right] - L_i, i = 1, 2 \tag{2}$$

Naturally, we assume that B is larger than C_i and C_j, since firms do not have an incentive to lobby for a contract that is not profitable. To assure that there is a unique maximum for L_i and L_j, which maximizes the profit functions of firms i and j, we assume that the profit function and, consequently, the probability function is concave in L_i and L_j. We also have to assume that the probability function is continuous and twice differentiable. Finally, we assume that the cross derivatives of the probability function are negative, as will be discussed shortly. These conditions are sufficient but not necessary for the existence of a stable, Nash-Cournot equilibrium. Concavity implies that the Hessian matrix must be negative definite. Solving the determinant of the Hessian matrix, concavity implies that:

$$\frac{\partial^2 P}{\partial L_i^{\,2}} < 0 \tag{3}$$

$$\frac{\partial^2 P}{\partial L_i^{\,2}} \times \frac{\partial^2 P}{\partial L_j^{\,2}} > \left(\frac{\partial^2 P}{\partial L_i \partial L_j} \right)^2 \tag{4}$$

We assume, for simplicity, that both firms are risk-neutral and, therefore, attempt to maximize their expected profits. From equation (2), we get the two first order conditions, which are the reaction functions for the two firms.

$$\frac{\partial P}{\partial L_i} = \frac{1}{(B - C_i)} \tag{5}$$

We derive the slopes of the reaction functions using the implicit function theorem.

$$\frac{dL_i}{dL_j} = -\frac{\dfrac{\partial^2 P}{\partial L_i \partial L_j}}{\dfrac{\partial^2 P}{\partial L_i^{\,2}}} \tag{6}$$

Concavity implies that the second order derivative of the probability function with respect to L_i is negative, but we must also assume something about the cross-derivates of the probability function. It is reasonable to assume that the cross-derivatives are negative because if firm j increases its lobbying effort, then additional lobbying by firm i is likely to have a smaller effect on firm i's probability of winning the contact. Thus, we assume:

$$\frac{\partial^2 P}{\partial L_i \partial L_j} < 0 \tag{7}$$

Let us denote the reaction functions as $L_i(L_j)$, which represent the lobbying effort that firm i would choose given the effort of firm j, and $L_j(L_i)$, which represent the lobbying effort that firm j would chose given the effort by firm i. We can draw the two reaction functions on a graph with L_i on the X-axis and L_j on the Y-axis.

Figure 1 shows the Nash-Cournot equilibrium levels of lobbying efforts, denoted as L_i^* and L_j^*. We can show that the slope of $L_i(L_j)$ is smaller (hence steeper) than the slope of $L_j(L_i)$ by multiplying equation (4) by -1 and rearranging. Therefore, the concavity of the probability function assures that this equilibrium is globally stable, which means that for any levels of L_i or L_j, the two firms will converge to L_i^* and L_j^* as can be seen from Figure 1. We define L_i^* and L_j^* in term of the exogenous variables in the model; namely, B, C_i, C_j, and γ.

$$L_i^* \left(B, C_i, C_j, \gamma \right) \tag{8}$$

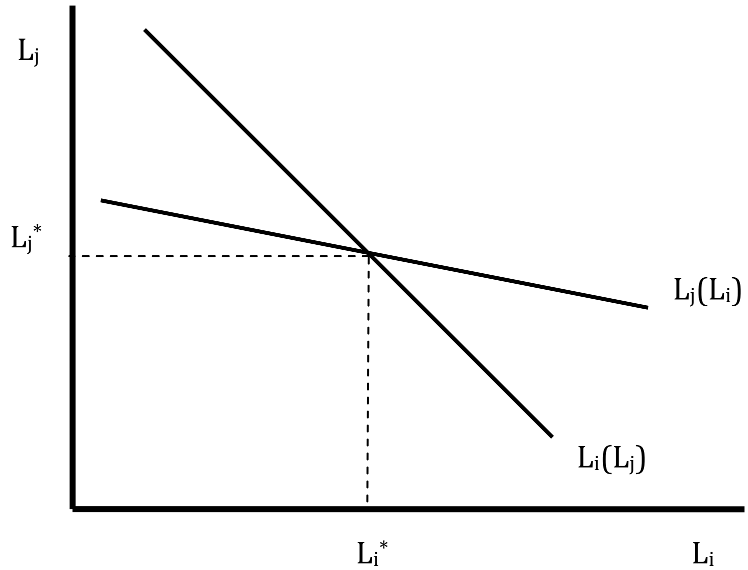

Figure 1: Equilibrium Levels Of Lobby Effort

Given our assumption that the cross-derivatives are negative - equation (7) - we can see from the first order conditions - equation (5) - that an increase in B or an increase in γ would shift the reaction functions of both firms up causing both L_i^* and L_j^* to increase. By contrast, an increase in C_i would shift $L_i(L_j)$ down, which would lead to a decrease in L_i^* but an increase in L_j^*. Similarly, an increase in C_j will shift $L_j(L_i)$ down causing L_j^* to decrease but L_i^* to increase, as shown in Figure 2.

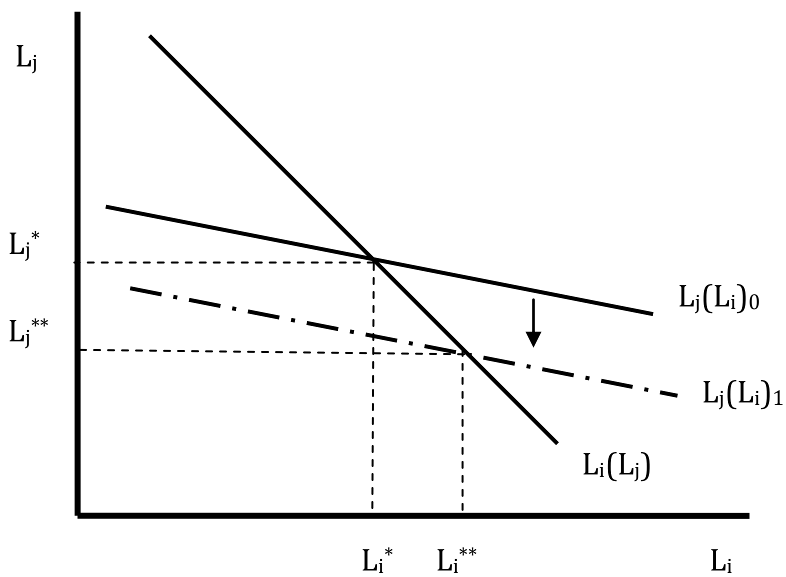

Figure 2: Shift In Equilibrium Due To An Increase In C_j

Total lobbying equals the sum of L_i^* and L_j^*. An increase in the size of the contract, B, or the factor of influence, γ, would always increase total lobbying since it will increase both L_i^* and L_j^*. On the other hand, an increase in either of the firms' costs would increase lobbying by one firm and decrease lobbying by the other firm.

We can show using Figure 1 that if the slopes of both reaction function are larger than -1 (shallower) or smaller than - 1 (steeper), then an increase in one of the firm's costs would increase the total amount of lobbying. However, if the slope of $L_i(L_j)$ is smaller (steeper) than - 1 and the slope of $L_j(L_i)$ is larger (shallower) than – 1, as is the case in Figures 1 and 2, then an increase in either of the firm's costs would decrease total lobbying by decreasing lobbying by that firm by more than the decrease in the other firm's lobbying (in absolute value). If the probability functions of the two firms are symmetric in L_i and L_j, then $L_i(L_j)$ must be smaller than -1 and $L_j(L_i)$ must be larger than -1 since the reaction functions will be mirror images of one another. Therefore, if the probability functions are symmetric, then an increase in either of the firms' costs would decrease total lobbying.

A SPECIFIC MODEL

In order to demonstrate how the model works and to solve for the equilibrium levels of lobbying, we consider a specific probability function. Let P^i be the probability that firm i wins the contact. We select a simple probability function.

$$P^i(L_i, L_j) = .5 + \gamma \frac{L_i - L_j}{L_i + L_j} \tag{9}$$

We assume that the factor of influence is between 0 and .5, $0 \le \gamma \le .5$. If the factor of influence is zero, then lobbying has no influence on the government's decisions and each firm has an equal probability of winning the contract, $P^i = .5$ for i = 1, 2. Note that $0 \le P^i \le 1$ and $P^i + P^j = 1$. Also, P^i increases when L_i increases and decreases when L_j increases. Hence, equation (9) meets all the requirements that we specified for the probability function. Substituting equation (9) into the expected profit function, equation (2):

$$\mathrm{E}[\Pi^i] = \left(.5 + \gamma \frac{L_i - L_j}{L_i + L_j} \right) \left[B - C_i \right] - L_i \tag{10}$$

We assume, for simplicity, that both firms are risk-neutral and therefore maximize their expected profits. Each firm chooses a level of lobbying that would maximize its expected profit given the factor of influence, the size of the contract, its production cost, and the lobbying effort of the other firm. We obtain the reaction function of each firm by rearranging the first order derivative of its expected profit function.

$$\frac{2\gamma\left(B - C_i\right)L_j}{\left(L_i + L_j\right)^2} = 1 \tag{11}$$

Simultaneously solving the two reaction functions, we obtain the equilibrium levels of lobbying effort for both firms.

$$L_i^* = \frac{2\gamma\left(B - C_j\right)\left(B - C_i\right)^2}{\left(2B - C_i - C_j\right)^2} \tag{12}$$

Note that if the factor of influence, γ, is zero, then both firms would choose a lobbying effort of zero, which makes sense since their lobbying would have no influence on policymakers. Furthermore, by subtracting L_j from L_i, we observe that L_i is larger than L_j if C_i is smaller than C_j. In other words, the firm with the lower production cost would lobby more and therefore would have a higher probability of winning the contract.

$$L_i - L_j = \frac{2\gamma\left(B - C_i\right)\left(B - C_j\right)\left(C_j - C_i\right)}{\left(2B - C_i - C_j\right)^2} \tag{13}$$

Taking the derivative of $L_{i,}$ with respect to the exogenous variables, we find that L_i increases with an increase in the factor of influence, γ, and decreases with an increase in the cost of the firm, C_i. Firms are likely to increase their lobbying when policymakers become more easy to influence; for instance, before a close election. Furthermore, the less lucrative the contract is; that is, the smaller $B - C_i$, the less money the firm would spend lobbying to gain it.

$$\frac{\partial L_i}{\partial \gamma} = \frac{2\left(B - C_i\right)^3}{\left(2B - C_i - C_j\right)^2} > 0 \tag{14}$$

$$\frac{\partial L_i}{\partial C_i} = -\frac{4\gamma\left(B - C_j\right)^2\left(B - C_i\right)}{\left(2B - C_i - C_j\right)^3} < 0 \tag{15}$$

By contrast, the response of firm i to an increase in firm j's cost depends on the relative size of their production costs, as shown in equation (16). If firm i has a lower production cost than firm j, then an increase in the cost of firm j will lead firm i to decrease its lobbying effort. This occurs because if $C_i < C_j$, then firm i is already lobbying more than firm j; consequently, if firm j's cost increases causing it to lobby less, it makes sense for firm i to save its lobbying dollars because the marginal effect of its lobbying is relatively low since L_i is already large.

$$\frac{\partial L_i}{\partial C_j} = \frac{2\gamma\left(C_i - C_j\right)\left(B - C_i\right)^2}{\left(2B - C_i - C_j\right)^3} \qquad 16)$$

When the benefit of the project, B, increases, both firms will increase their lobbying effort, as shown in equation (17). Therefore, a government would receive more lobbying dollars if it offered more lucrative projects or became more easily influence; that is, if γ increased.

$$\frac{\partial L_i}{\partial B} = \frac{2\gamma\left(B - C_i\right)\left[\left(C_j - C_i\right)^2 + \left(B - C_i\right)\left(B - C_j\right) + \left(B - C_j\right)^2\right]}{\left(2B - C_i - C_j\right)^3} \geq 0 \tag{17}$$

CONCLUDING REMARKS

This paper examines a game-theoretical model in which a duopoly competes for a lucrative government contract. For example, Lockheed Martin and McDonnell Douglas may compete for government contracts to build new military planes. Similarly, Exxon Mobil and Chevron may compete for the rights to drill in certain areas. Unlike previous research, we focus on the strategic interaction between the lobbyists and utilize a winner-take-all model where each firm can increase its probability of winning the contract by increasing its lobbying effort.

We begin by examining a model with a general probability function. We conclude that if the probability function is concave, continuous, and twice differentiable and the cross-derivatives are negative, then there exists a unique, globally-stable Nash-Cournot equilibrium. Our assumptions are sufficient but not necessary for the existence of a stable equilibrium. We show that an increase in the size of the contract or an increase in the factor of influence will increase lobbying by both firms and, therefore, increase total lobbying. On the other hand, an increase in one of the firm's production cost would lead that firm to reduce its lobbying, but would lead the other firm to increase its lobbying; therefore, the net effect on total lobbying depends on the structure of the probability functions. For examples, if the probability functions are symmetric for the firms, then an increase in either of the firms' costs would lead to a decrease in total lobbying.

Next, we utilize a model with a specific and relatively simple probability function. We show that it is possible to express the Nash-Cournot equilibrium levels of lobbying in term of the exogenous variables. As expected, the level of lobbying would increase with the size of the contract and with the factor of influence. Thus, as expected, corrupt governments that offer lucrative contracts are likely to receive more lobbying dollars. Furthermore, if the production cost of one firm increases, it would lead that firm to reduce its lobbying effort but could lead the other firm to increase or decrease its lobbying effort, depending if it has a higher or lower production cost than the first firm. Consequently, an increase in the production cost of one of the firms could increase or decrease total lobbying effort.

Future research can expand on this paper by attempting generalizing the model to n firms. We anticipate that more competition for a government contract (i.e., a higher n) would result in higher total lobbying and, consequently, less profit for the firms. Furthermore, an increase in the number of firms will cause an increase in one of the firm's costs to have a larger reduction in firm's lobbying efforts but a smaller effect on total lobbying. The model can also be expanded into a two-stage game where firms first submit bids for a contract (hence, each firm has a different benefit if it wins the contract) and then lobby to win the contract. Under such a model, a firm can increase its probability of winning a contract by either lowering its bid or by increasing its lobbying effort. We hypothesize that if the factor of influence is high, then firms will focus on lobbying; but if the factor of influence is low, then firms will focus on submitting a lower bid.

AUTHOR INFORMATION

Dr. Yoav Wachsman is an Associate Professor of Economics at the E. Craig Wall Sr. College of Business Administration at Coastal Carolina University. He received his Ph.D. in economics from the University of Hawaii at Manoa in 2003. Prior to working at Coastal Carolina University he worked as research assistant on the Hawaii Health Coverage for All Project and as an industrial economist for the National Marine Fisheries Service. His areas of specialization are Applied Microeconomics, Natural Resource Economics, and Economics of Tourism. E-mail: yoav@coastal.edu (Corresponding author)

Dr. Jie Zhou received his Ph.D. in mathematics from University of Georgia in 2006. Currently he works as an Assistant Professor of Mathematics and Statistics at Coastal Carolina University. His areas of specialization are Wavelet Analysis, Numerical Analysis, and Splines. Besides mathematics, he has a strong interest in finance and economics. E-mail: jzhou@Coastal.edu

REFERENCES

1. Bhagwati, J.N. (1982). "Directly-unproductive Profit Seeking Activities." *Journal of Political Economy*, 90, 899-1022.
2. Epstein, G.S. and S. Nitzan (2006). "Lobbying and Compromise." *Public Choice*, 126, 317-30.
3. Felli, L. and A. Merlo (2001). "Endogenous Lobbying." PIER Working Paper Archive 04-043, Penn Institute for Economic Research, Department of Economics, University of Pennsylvania.
4. Felli, L. and A. Merlo (2006). "Endogenous Lobbying." *Journal of the European Economic Association*, 4, 180–215.
5. Felli, L. and A. Merlo (2007). "If You Cannot Get Your Friends Elected, Lobby for Your Enemies." *Journal of the European Economic Association*, 5(2-3), 624-35.
6. Grossman, G.M. and E. Helpman (1996), "Electoral Competition and Special Interest Politics", *Review of Economic Studies*, 63(2), No 3-5, 265-86.
7. Grossman, G.M. and E. Helpman (2001), *Special Interest Politics*, Cambridge MA and London UK: The MIT Press.
8. Hillman, A.L. and D. Samet (1987). "Dissipation of Rents and Revenues in Small Number Contents," *Public Choice*, 54, 63-82.

9. Horgos, D. and K.W. Zimmermann (2009). "Interest Groups and Economic Performance: Some New Evidence." *Public Choice*, 138, 301-15.
10. Horgos, D and Klaus W. Zimmermann (2010). "It Takes Two to Tango: Lobbies and the Political Business Cycle." *KYKLOS*, 63(3), 383–99.
11. Kahane, L.H. (2002). "Rice, Salmon or Sushi? Political Competition for Supply of a Regulated Input." *The American Economist*, 46(1), 22-28.
12. Olson, M. (1965). *The Logic of Collective Action*. Cambridge: Harvard University Press.
13. Tullock, G. (1967). "The Welfare Costs of Tariffs, Monopolies and Theft." *Western Economic Journal*, 5, 224-232.

